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SECTOR ANALYSIS AND MODELS OF AGRICULTURE IN DEVELOPING COUNTRIES†

The preparation of sector programs for agriculture in developing countries must be based on an analysis of the sector. There are at least three aspects of sector analysis which should be distinguished: (a) the theoretical or conceptual underpinning, (b) the formulation of quantitative models (or partially quantitative-qualitative frameworks) within which the structure and the performance of the sector can be studied empirically and policy recommendations generated, and (c) the selection and preparation of a concrete program at the sector level.

The purpose of this paper is twofold. First, it offers a selective typology of agricultural sector models. A critical review and evaluation of a number of concrete models corresponding to each type above is undertaken. Since the specification and design of these models tend to emphasize different theoretical considerations and rely on different techniques, this first part addresses itself to the first two aspects of sector analysis mentioned above. The second part of the paper deals in somewhat general terms with the third aspect, i.e., the preparation of sector programs in practice and the requirements of various users of sector analysis, such as national ministries, planning commissions, and bilateral and multilateral donor agencies.

The theoretical basis of sectoral analysis is derived from the body of macro- and microeconomic theory. As such, it has to face such intractable problems as that of the aggregation of the microbehavior of the farm as a producing and consuming unit and the disaggregation (or decomposition) of the agricultural sector from the macroeconomy. Whereas the state of both macro- and microeconomic theory is relatively advanced, that of "sector theory" is still at an early state of development in the professional literature.

The quantitative specification and description of the structure and performance of the agricultural sector (i.e., the modelling aspect of sector analysis) is constrained by the state of the arts ("sector theory") from which it borrows its hypotheses and techniques and the availability of data. The purpose of a sector

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model should be to capture the most important structural and behavioral relationships within agriculture and between agriculture and the rest of the economy, on the one hand, and to be potentially useful to the policymaker as a planning tool to help select and formulate a sector program, on the other hand.

In practice, however, sector programs and agricultural policies, in general, are designed on an ad hoc basis without the help of explicit sector models. There are at least two supporting reasons why policymakers, as a rule, do not rely on sector models. First, very few such models have actually been constructed for and applied to developing countries and, secondly, most existing sectoral models are experimental in nature and thus of only limited use for policy purposes.

A TYPOLOGY AND CRITICAL EVALUATION OF AGRICULTURAL SECTOR MODELS

It has already been pointed out that there are very few models which describe quantitatively the agricultural sector of developing countries.¹ An attempt is made here to review and evaluate critically a selected number of the more representative of these models and, in that process, provide a classification scheme.

It is important, at the outset, to specify conceptually the domain of sector analysis and models and the hierarchy of linkages which can, and should ideally, be incorporated into a sector model. Starting at the most micro level, the unit of observation is the farm (F) as a producing firm and as a consuming household. Farms can be grouped together on the basis of certain criteria (e.g., technique of production, size of the land holding, quality of land) into districts (D) which represent the first level of aggregation. Agricultural districts, in turn, can be consolidated to form a region (R) according to climatic, economic, or even administrative factors. The agricultural sector (A) can be composed of a number of regions. Finally, agriculture has to be linked to the rest of the national economy (E) as well as to the world economy (W).

Chart 1 shows this hierarchy of linkages in a schematic way. Ideally, the sector model should embrace explicitly the relationships within and between agricultural subsets (F-D; D-R, or at least F-R; and R-A) and the links with the rest of the economy (A-E) and the outside world (foreign trade and investment linkage) directly (A-W) or through the national economy (A-E-W). In a sense, the system to be modeled is one in which each set is a subset of a higher order set.²

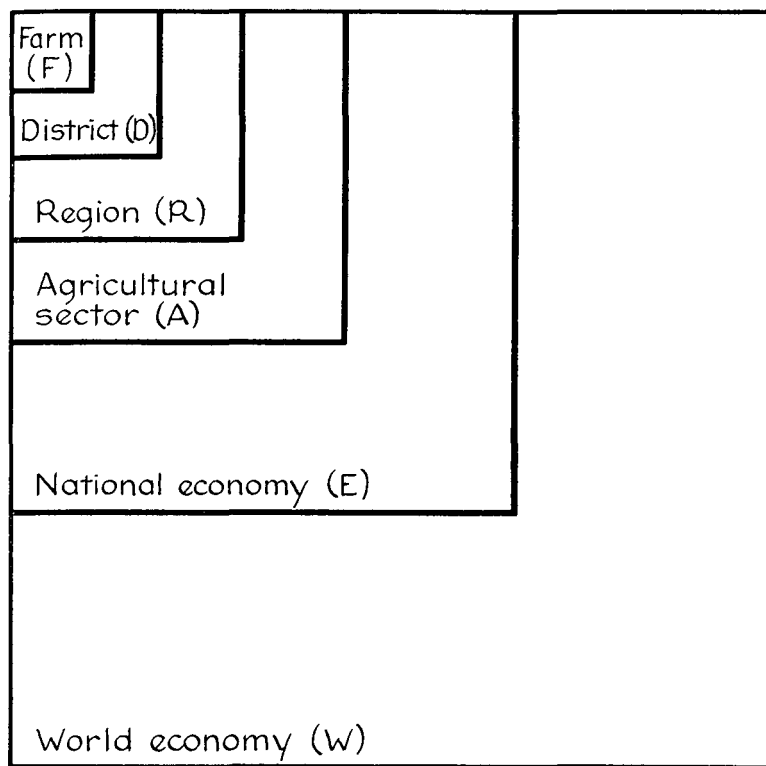
It will be seen in the review of sector models that the above scheme is a useful one and an important criterion in classifying models according to the sets (domains) and links which are emphasized. Thus, some models are built from the "bottom up," i.e., they start by describing the purely microbehavior of farms and proceed to aggregate at the district and regional level, whereas other models are built from the "top down" starting at the macroeconomic level, which is subsequently disaggregated into an agricultural sector and component regions.

The accompanying table provides a breakdown of sector models into the fol-

¹ There are a number of national and regional agricultural models which have been built for developed countries. For a review of these, see E. O. Heady (5). The operational usefulness of these models for policy purposes appears to be limited at this time in both East and West.

² A complication in the above scheme is that districts and regions are spatial units in which agricultural and nonagricultural activities take place. Thus, the latter have to be described in the specification of rural districts and regions.

CHART 1.—HIERARCHY OF LINKAGES*



* See text for alternative nongeographical definitions of districts and regions.

following four distinctive classes according to a number of characteristics and criteria: (a) multilevel planning models; (b) microeconomic-dynamic models; (c) simulation-systems models; and (d) general equilibrium-consistency models. The major characteristics and criteria used in the table refer to the form of the model, i.e., (i) is it of an optimization or consistency type? (ii) is it one-period or dynamic? (iii) does it have a micro- or macro-orientation? In addition, the models are classified according to the major links (such as farm-region or sector-economy) which they emphasize, the techniques and methods which they use, and the ways in which technological alternatives and migration activities are incorporated into them.

Prototype examples corresponding to each class are presented next and reviewed critically on the basis of the above set of criteria and others, such as the form of the preference functions, and major policy objectives contained in the various models; the principal policy problems addressed in the sector models and their operational usefulness to policymakers; and some estimates of resource costs and transferability of the methods or results.

Multilevel Planning Models

Perhaps the best examples of such models are those being built presently by the Development Center of the International Bank for Reconstruction and De-

CLASSIFICATION OF SECTOR MODELS

Characteristics	Conceptual framework, type of model					
	Multilevel planning models		Microeconomic-dynamic models	Simulation-systems models	General equilibrium-consistency models	
Examples ^a	1	2	3	6	7	8
Consistency or Optimization	x		x	x		x
One-period or Dynamic	x		x	x		x
Micro-orientation or Macro-orientation	x		x	x		x
Formal links						
Farm-Region			x			
Farm-Sector						
District-Region	x					
Region-Sector	x			x		
Sector-Economy	x			x		x
Methods and techniques						
Programming	x					
Recursive programming			x			
Recursive systems analysis				x		
Various methods ^b				x		x
Technological alternatives incorporated at						
Farm level			x			
District level	x					
Regional level				x		
Sector level						x
Migration activities included at						
Regional level	x		x	x		
Sector level						x

^a Numbers refer to specific models (see list of references at the end of the article).

^b Including nonquantitative description.

velopment (IBRD) and applied to Mexico and the Ivory Coast (6; 14). The main characteristic of these models is the formal linkage of a multisectoral economy-wide model with an agricultural model which is further decomposed into a number of district submodels which are grouped together into four regions. Thus, the E-A-D links are formally introduced (see Chart 1). Since there are three levels of planning, solutions can be obtained at the economy-wide level, at the agricultural sector level, or at the district level.

The Mexican model designed by John Duloy and R. D. Norton with the help of the Mexican government is basically a programming model of the agricultural sector (6). Agriculture is subdivided into twenty district submodels on the basis of climatic conditions (e.g., irrigated vs. rain-fed areas, soil fertility, and eleva-

CHART 2.—STRUCTURE OF CONSTRAINTS IN MULTILEVEL PLANNING MODELS*

	Activities			Constraints
Economy (E)				Balance of payments; investment-savings
Sector (S)				Credit; machinery
Region (R) I				Hired labor; chemical inputs
Region II				Hired labor; chemical inputs
Region III				Hired labor; chemical inputs
District (D) 1				Land; water; farmers' labor
District 2				Land; water; farmers' labor
District 3				Land; water; farmers' labor
District 4				Land; water; farmers' labor
District 5				Land; water; farmers' labor
District 6				Land; water; farmers' labor
District 7				Land; water; farmers' labor
District 8				Land; water; farmers' labor
District 9				Land; water; farmers' labor

*In the Mexican model discussed in the text there are 2,500 activities for the 40 major crops.

tion). These submodels, in turn, are grouped into four main geographical regions. Cropping and investment activities are specified for each submodel.

Chart 2 shows the structure of constraints which is specified in the Mexican model. Certain inputs, such as land, water, and the farmers' own labor, are supplied and specified as constraints at the district level, other inputs such as hired labor and chemical inputs appear as regional constraints, and still others (credit and machinery services) are treated as sectoral constraints. Finally, when the agricultural model is linked with the multisectoral economy-wide model, certain central constraints (balance-of-payment, total investment) are specified at the national level. The nature of the constraints makes it possible to express the model in a block-diagonal way with respect to the districts—as can be seen from Chart 2. For any activities (e.g., crops produced according to a given technology) certain

inputs are supplied and constrained at the national, sectoral, regional, or district levels. Thereby each district submodel can be solved independently or the whole agricultural model can be run and solutions obtained at the sectoral level.

The sector-wide model contains about 2,500 cropping activities to describe alternative technologies (e.g., mechanized and nonmechanized) for producing the 40 major Mexican crops. Demand functions are specified nationally taking transportation costs into consideration. However, it is not assumed that each submodel area can equally well supply the "national" market. Spatial price differentials are used to reflect the differential transport costs faced by each submodel. Product prices are endogenously determined.

The sector model contains a detailed treatment of employment and seasonal migration.

At least two different objective functions can be postulated and the model solved accordingly to simulate the agricultural sector behaving either as a monopolistic supplier of products or, more realistically, as a collection of competitive producers.

At this stage the model is designed to address itself to questions of pricing policies for both inputs and outputs, trade policies, employment programs, and the effects of certain investment projects. At a later stage when the agricultural sector model is formally linked to the economy-wide model (DYNAMICO),³ the effects of investment projects on a district could be analyzed within a general equilibrium framework. In other words, the impact of a large project or set of projects could be followed through logically and quantitatively on the district, the region, the sector, and ultimately the national economy. If the above linkages could be accurately captured and reflected in the marriage of CHAC (the agricultural model) and DYNAMICO, such a general equilibrium treatment of the effects of projects could potentially revolutionize the methodology of project analysis.

So far, only limited numerical results have been obtained. Evidence that this study is of interest to the policymakers is the fact that work is proceeding in Mexico at the present time to strengthen the operational usefulness of the model. In the meantime, some methodological elements of the model might well be transferable in the design of other sector analyses. Among these would appear to be the decomposition algorithm (e.g., the treatment of central and district constraints), the treatment of labor supply and migration (e.g., different reservation prices are postulated for different labor skills and types), and perhaps some aspects of the substitutability between labor and capital in production activities.

The sector study has been a fairly major undertaking involving about seven man-years of professionals' time and coordination with a number of Mexican government agencies (e.g., the Banco de Mexico and the National Agrarian University).

The Ivory Coast model (14), which is based on a conceptual framework quite similar to that of the Mexican model, places more emphasis, however, on ques-

³ The formal linkage between the multisectoral, economy-wide model (DYNAMICO), built by A. Mann, and the agricultural model is presently under way. The agricultural model—baptized CHAC for the rain god of the Maya—was started after DYNAMICO had already been specified, which makes the linkage between the two more difficult.

tions of seasonal employment and migration, income distribution, and the role of education in creating employment (and income) and in affecting the income distribution.

Microeconomic-Dynamic Models

This class of models is represented by the collaborative work of R. H. Day (1), M. S. Mudahar (9), Inderjit Singh (11), and others.

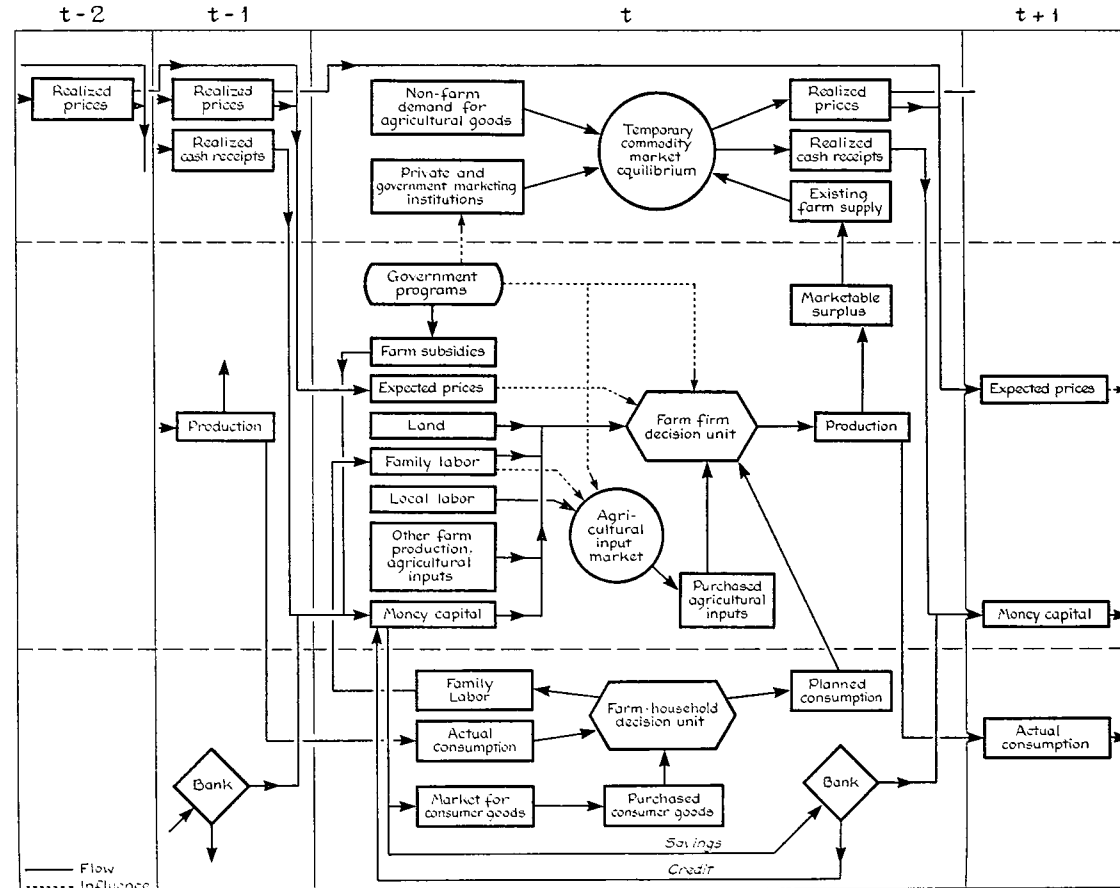
In contrast to other sector models, this type of model is built entirely from "the bottom up." The unit of observation is the farm as a producing firm, on the one hand, and as a consuming household on the other. The model was applied to Punjab agriculture—in that sense it is a regional rather than a national sector model. The two most important and distinctive features of this approach are the form of the preference function of the farmer as decision-maker and the way the model is made dynamic. The preference (objective) function of the farmer is postulated in a lexicographic way. In other words, four major objectives are specified at the micro level, ranked in terms of absolute priority (lexicographic ordering): (a) satisfying subsistence consumption needs; (b) a utility function comparing cash consumption and future income; (c) a safety-first objective; and (d) maximization of net cost returns. Thus, the model is solved through maximizing a lexicographic utility function subject to stringent constraints. What is truly distinctive in this model is that the maximization procedure is undertaken at the farm level. It is felt by the authors that the traditional behavior of farmers is well captured and described by the above function.

The dynamic elements are introduced through recursive programming. Thus, for example, the farmer's decisions in year t are influenced by past output prices, past realized sales and savings, and, in general, depend recursively on the previous period's solutions. As Mudahar pointed out, "This intertemporal recursive interdependence generates environmental feedback functions which, once explicitly included, . . . (make) the model a 'short-sighted' dynamic model of decisions" (9, p. 14). Chart 3 shows the structure of the model and its major relationships both intra- and intertemporal.

The model contains the following activities: (a) production activities by type of technology, by crop, and by season; (b) investment activities for variable inputs and capital; and (c) household activities which include subsistence consumption, commercial consumption, cash savings, and labor-supplying on and off farms. As was pointed out previously, the above activities recognize the farm unit as a household and a firm which has linkages to external sectors. (See Chart 4 for description of intrafarm and farm-market linkages.) Various constraints are imposed on inputs, borrowing, adoption, subsistence, consumption-savings, and safety.

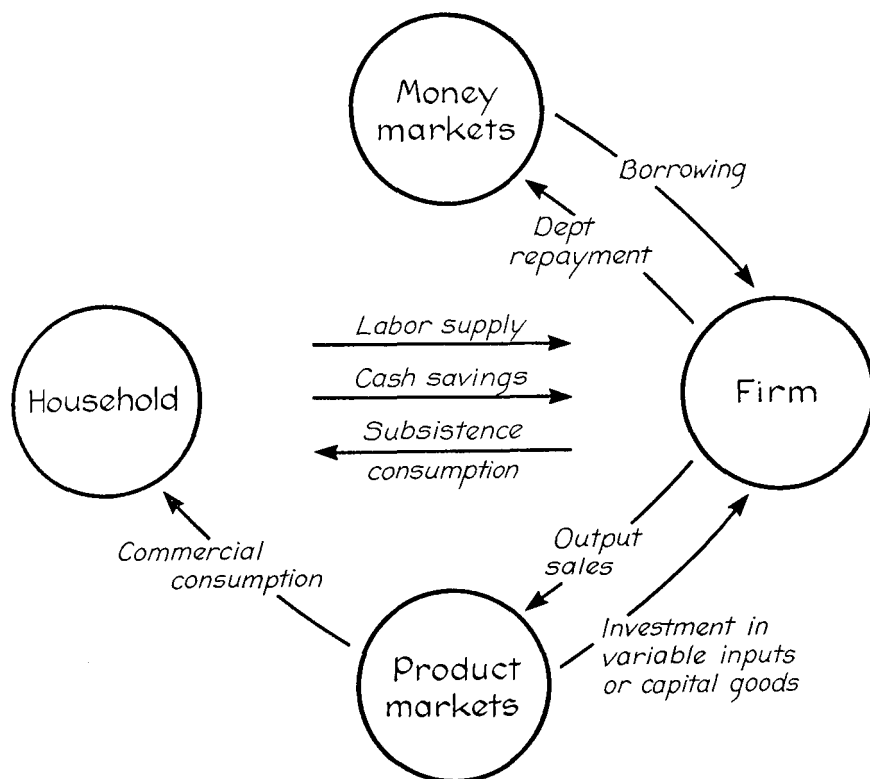
There are certain questions which do not appear to be adequately treated to qualify this type of model as a full-fledged sector analysis, i.e.: the aggregation of production and demand; and the interaction between Punjab agriculture, the rest of Indian agriculture, and the economy as a whole. Some limited empirical results have been obtained—although no run has yet been made on the complete model. For these reasons, the operational usefulness of this type of model has not yet been tested. However, work is proceeding on the specification and estimation

CHART 3.—THE STRUCTURE OF A MICRODYNAMIC AGRICULTURAL DEVELOPMENT MODEL*



* From M. S. Mudahar, "A Dynamic Microeconomic Analysis of the Agricultural Sector: The Punjab" (9).

CHART 4.—MICRODYNAMIC MODEL, INTRAFARM AND FARM-MARKET LINKAGES*



* From R. H. Day, Inderjit Singh, and M. S. Mudahar, "A Dynamic Microeconomic Model of Agricultural Development" (1).

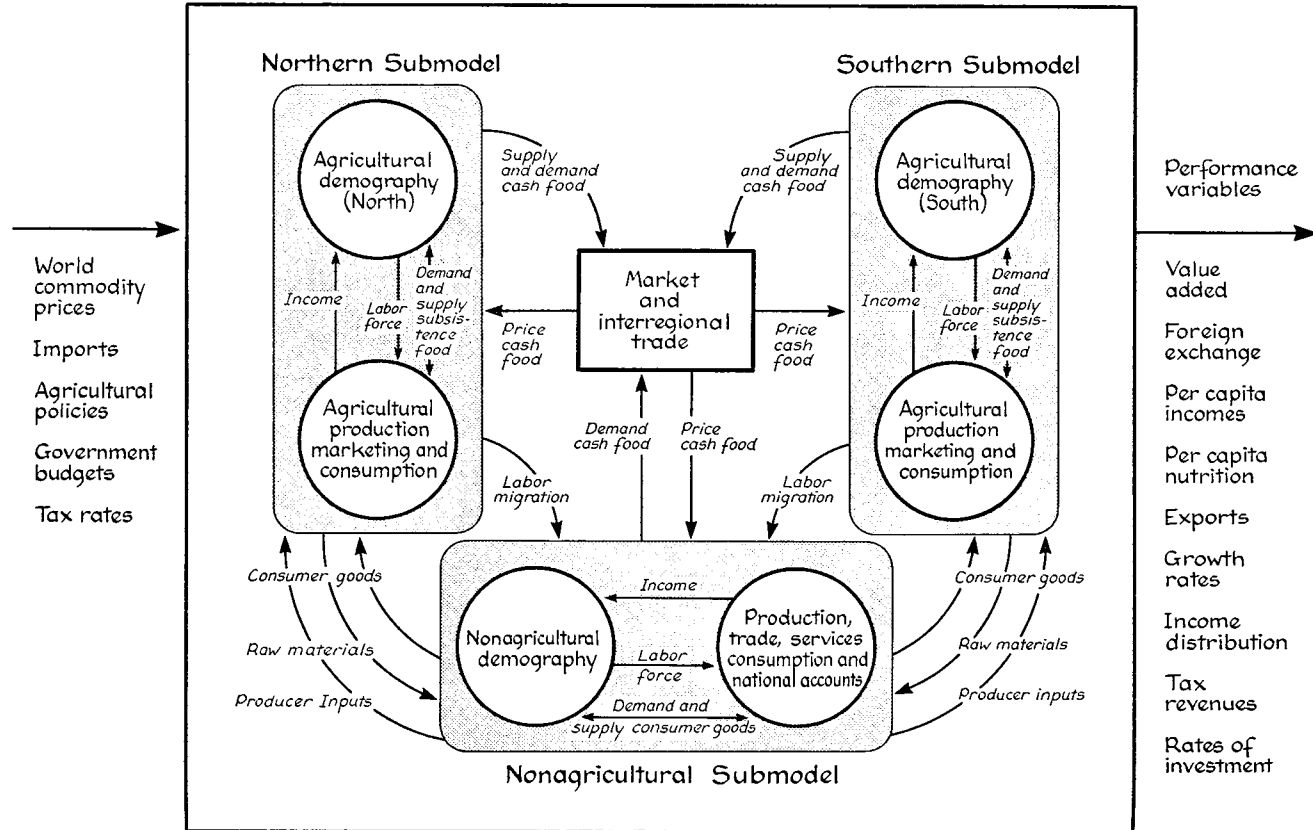
of this type of model and it may one day prove useful for policy purposes. (Singh, for example, is applying this methodology to Brazil.)

The resource cost so far would probably run into five man-years of professional talent and fairly large computing expenditures. There are, at least, two elements of this study which might be transferable from a methodological standpoint: first, the microeconomic, dynamic emphasis, and, secondly, the novel and presumably realistic treatment of the farmers' preference function. The latter should be empirically tested to determine the extent to which it actually explains the behavior of farmers. An empirical confirmation of the hypotheses underlying that preference function would be an important contribution to a better understanding and quantitative description of the development process.

Simulation, Systems-Science Model

The prototype of this class of model is that developed over the last five years by an interdisciplinary group at Michigan State University under the direction of Glenn L. Johnson (7). It is a very large scale model of Nigeria's agriculture, broken down into three interacting submodels corresponding to, respectively, (a) Northern Nigerian agriculture; (b) Southern Nigerian agriculture; and (c) the rest of the economy. The model is basically a consistency-type model. The

CHART 5.—SIMULATION-SYSTEMS MODEL OF NIGERIA: NATIONAL MODEL OF INTERACTING SUBMODELS*



*Based on G. L. Johnson et al., "A Generalized Simulation Approach to Agricultural Sector Analysis with Special Reference to Nigeria" (7).

results of changes in exogenous variables, policy instruments, and technology can be simulated within the model. In that way, a number of alternative "development plans" can be generated.

The two regional agricultural submodels contain production, marketing, and consumption activities for a number of crops which provide income to each respective population. In turn, changes in income and population levels determine demand functions and labor movements within each regional model. The regional submodels are linked with the nonagricultural submodel through incoming flows of consumer goods and producer inputs and outgoing flows of raw materials. Chart 5 shows the network of causal relationships between the three submodels. As can be seen from Chart 5, the model can simulate interregional trade in food and labor migration. Land, and so-called modernizing inputs, are combined into the sectoral submodels to reflect technological alternatives.

Basically, the model was built in an eclectic fashion from a large number of "building blocks" representing the physical, biological, economic, social, political, and cultural relationships existing within and among the major sectors of the economy. These building blocks, as the authors indicate, "are composed of interrelated functional relationships which can be broken apart into more manageable components because of their recursive nature (i.e., one function necessarily follows another in time and is dependent upon the output of the previous function) or their seeming independence (geographic, behavioral) at any one point in time (7, p. 12). The specification of these various relationships appears to be done on an ad hoc basis; in some cases parameters are selected on a priori grounds, in other cases they may be based on statistical estimation, in still others on researchers' judgments.

The overall model consists of over 2,000 equations, only a fraction of which are presented in symbolical form (7). The nonagricultural submodel is the only submodel explicitly presented—at least functionally. The latter is based on a ten-sector input-output framework. Examples of policy problems which can be potentially addressed within the model are the impact of changes in such policy means as prices paid to export crop producers, research, public investment allocation, and import substitution on such policy objectives as farm and non-farm income, per capita nutrition, balance-of-payments, and employment. Even though a number of tests have been run to check the ability of the model to replicate changes which occurred during the historical (sample) period, considerably more work might be required before the model can be used by policymakers.

The work completed under the Nigerian consortium was financed by relatively large research grants and contracts from the Agency for International Development (AID). On the whole, it appears that the Nigerian study required very substantial resources. Approximately ten man-years of professionals, coming from a variety of disciplines (e.g., economics, agriculture, systems- and computer science), have been required.

It is clear that some important methodological contributions might result from this project, particularly with regard to the design of interacting submodels, the cross-fertilization of different disciplines, and a critical determination of these relationships and parameters with regard to which results are sensitive.

The sheer size of the model, combined with the impossibility of checking

the underlying assumptions, quantitative specification, and the explanatory power of the multitude of building blocks forming the model make it very difficult, at this time, to evaluate the quality and overall performance of the model critically. It is clear, however, that certain activities are very thoroughly and accurately described such as the dynamic treatment of perennials and population growth. Other activities such as employment and labor migration appear to be rather superficially specified.⁴

General Equilibrium-Consistency Frameworks

Sector analyses of this type tend to be much more "open ended" than the previous models, using a variety of methods and techniques.⁵ Representative examples of such sector analyses are the Fletcher-Merrill-Graber-Thorbecke study of Guatemala (2) and sector studies the Food and Agriculture Organization (FAO) is presently engaged in, in connection with its "Perspective Study of World Agricultural Development" program in Latin America (see 12 for underlying methodology), and particularly in Colombia.

The framework used in preparing the sector study of Guatemala is of a general equilibrium type. It is a broad based study and analysis of Guatemala agriculture within the context of the national economy. Thus, it is an attempt at describing and analyzing the agricultural sector within a consistency setting, emphasizing the role of agriculture in the overall process of economic development of the country.

The sector analysis is built essentially from the "top down." A relatively simple macroeconomic model of the economy was constructed to describe quantitatively the major structural and behavioral relationships between macroeconomic variables—and particularly the impact of exports, changes in the international terms-of-trade and foreign investment on gross domestic product (GDP), domestic investment, and the balance-of-payments—during the recent historical period (1960–67). This model was subsequently used to obtain consistent macroeconomic projections over the planning period (to 1975). Thus, the above macroeconomic model provided the link between the world economy and the national economy (the E-W link in Chart 1) so essential in a country as dependent on trade as Guatemala.

The macroeconomic projections obtained through the model provided, furthermore, a cadre within which agricultural production and consumption had to be consistent.⁶ In other words, agricultural demand projection by commodity groups had to be consistent with the projected growth rates of GDP and population and the prevailing income elasticities of demand and exogenously determined foreign

⁴ A similar simulation-systems model is presently being built for South Korea.

⁵ In that sense they can be better described as conceptual frameworks rather than "closed" models.

⁶ The lack of any input-output table for Guatemala made it impossible to perform a formal input-output consistency check. Such a check would help insure that the sectoral growth rates of gross output and value added are mutually consistent with and correspond to a given (projected) growth rate of GDP obtained from the macro model. Thus, agricultural demand projections would have to be consistent with given income elasticities of demand for food and raw materials, and agricultural production would have to be in line with the intersectoral production structure of the economy as given by the I-O coefficients. This type of I-O consistency check was undertaken in a study of Peru which used a very similar methodology (see 13). Further reference to this study is made subsequently in the text.

demand. Likewise, agricultural production had to be consistent with the overall growth of the economy in terms of, e.g., availability of capital and intermediate inputs. In this way, the link between the economy and agriculture was established (E-A).

No formal quantitative model of the agricultural sector was built. The approach used can be described as an attempt to study and analyze the contributions of agriculture to the major national policy objectives—output, employment, income distribution and the balance-of-payments. The nature of the sector study was strongly policy-oriented. Within the agricultural sector, the framework consisted of a quantitative analysis of the structure of agricultural production; the marketing system; government policies and programs; projections of demand for and supply of goods and considerations of alternative policies to improve the performance of the sector. The lack of data and time as well as the necessity for operational usefulness imposed serious limitations on building a complete quantitative model.

The central concern of the study was to identify policies to promote development and welfare in the large subsistence agricultural subsector consistent with overall economic and social objectives. An agricultural strategy to achieve these goals was formulated and used as a basis for a sector program by the Guatemala government. The analysis itself was undertaken at the request of AID and enjoyed the cooperation of the host government. It appeared to have been instrumental in providing the rationale for a \$23 million agricultural-sector loan from AID.

The total resources for the study were relatively modest—a total of not more than two-and-one-half man-years of professionals from Iowa State University and Guatemala were involved.⁷ A full cost estimate of the study would probably not exceed \$100,000. The study was started in 1968 and essentially completed less than a year after initiation. The time pressure and relatively low cost of the study go a long way in explaining its limited scope (at least as compared to some of the previously reviewed models).

Because of its strong policy orientation and limited resources, the study was not meant to generate methodological breakthroughs or test the applicability of sophisticated quantitative techniques. The conceptual framework appears to be transferable to countries having some of the characteristics of Guatemala (e.g., economic and social dualism and heavy reliance on exports). The methodology has the advantage that it can be implemented with resources and data readily available to a developing country or donor organization. On the other side, the very simplicity of the study and its lack of reliance on an explicit quantitative model can be criticized. A number of quantitative elements are introduced which are sometimes inadequately empirically documented.

Another example of the consistency-framework to analyze agricultural development is given in 12, the methodology of which was applied to the case of Colombia by FAO (3). This approach will be discussed briefly in the next section.

⁷ The Guatemalan technicians were assigned by their agencies to the research group. It would appear that an indirect benefit of the project was the practical training received by these technicians in economic research and data gathering.

SECTOR ANALYSIS REQUIREMENTS OF USERS AND
PROGRAM PREPARATION

From the standpoint of users, agricultural sector analysis should help them in the preparation and planning of sectoral programs. At least two types of uses and users can be identified. At the more general level, sector analysis should ideally provide a quantitative diagnosis of the sector and an analytical framework capable of measuring approximately the effects of alternative policies and programs on policy objectives such as output, income distribution, employment, and the balance-of-payments. At the more specific level, sector analysis should help in the estimation of the direct and indirect effects of projects and ultimately in the selection of specific projects or sets of projects.

The relative importance of these two types of uses varies for different users. Thus, international agencies which are not directly involved in the lending process would normally be more interested in the more general aspect of sector analysis in providing guidance for agricultural policy in the short and long run. On the other hand, national and international agencies that engage in capital lending (and in some cases also technical assistance projects) would like sector analysis to complement whatever partial equilibrium methods and criteria they use in evaluating and selecting projects.

It appears clear that large bilateral and multilateral donor agencies such as AID, IBRD, and the Interamerican Development Bank (IDB) are very much interested in both of the above uses of sector analysis. As large lenders striving to help achieve economic and social development, these organizations want to choose and finance projects which are both credit-worthy and contribute to development objectives. The large size of their lending programs—in at least many countries—permits these agencies to exercise some leverage on the whole set of agricultural policies and programs. A sound, policy-oriented sector analysis can be of great assistance in helping these agencies to formulate their investment programs and to make overall policy recommendations ranging from agrarian reforms to structural and instrumental changes. Likewise, a national planning commission working jointly with the ministry of agriculture could benefit greatly from an operationally useful sector analysis. Another advantage which would accrue to a national agency which developed a formal sector framework or model is that it could trigger a learning-by-doing process. In other words, the process of coming up with a sector analysis would reveal data gaps and relationships between variables and links between subsectors which were inadequately specified. Furthermore, involving the policymaker or his representative (e.g., a planning commission) into the building process would lead to a dialogue between policyusers and technicians and, presumably, improve the operational usefulness of the sector analysis. It is not realistic at this time to expect a sector model to generate a concrete sector program. However, what can be expected is that it provides sufficiently concrete guidelines—regarding the effects of alternative policies and large projects on the major objectives—within which an agricultural program could be conceived.

Rather than listing the specific requirements which major users expect from sector analysis,⁸ a few examples of more partial approaches, falling short of sec-

⁸ A conference was held at Iowa State University under the auspices of the Agricultural Development Council (ADC) in May 1971 on Agricultural Sector Analysis and Planning. At that conference

tor models—which could help in the policy-formulation process—are discussed below. The critical evaluation of sector models undertaken in the previous section revealed that at the present time there is still a large gap between what the models can deliver and what the users need and desire for policy-formulation purposes. The gap has been narrowing and, in all likelihood, will continue to narrow as further work on these models proceeds. In a sense, we need a bridge between theory and practice. A number of difficult methodological problems have to be addressed and resolved by these models before they can satisfy the requirements of policymakers. It is no coincidence that the least sophisticated framework reviewed above (the so-called general equilibrium-consistency framework) appeared to be most useful for policy purposes—albeit falling quite short of satisfying fully the policymakers' desires for concrete and quantitative answers out of which a sector program could be prepared.

In the meantime, while waiting for more operational relevance on the part of these models, there are more modest approaches which might be helpful to policymakers, two of which are discussed briefly below.

The first approach is a variant of the "general equilibrium-consistency" framework. It was developed by FAO and applied to Colombia (3; 12).

This study was undertaken as part of FAO's "Perspective Study of World Agricultural Development and International Strategy for the Second Development Decade" as applied to Latin America (1971-72). It was started in response to the relatively strong evidence that unemployment and underemployment are increasing and that the income distribution is becoming more unequal in many parts of Latin America. Since a large share of the total labor force is in agriculture which contains, furthermore, a substantial traditional subsector where output per head is remaining stagnant at the subsistence level, any attempt at analyzing changes in employment and income distribution must concentrate on agriculture.

The setting of the problem is as follows: It is assumed that the economy will grow at a given GDP growth rate within a feasible range. As a policy objective, a given change in the existing income distribution can be set as a target. Consequently, the implication of different alternative income distributions on agricultural demand and the feasibility of achieving these income distributions, from the standpoint of the conditions and techniques under which the agricultural output is produced, can be explored.

The methodology underlying this approach is given in a paper prepared for FAO's Policy Advisory Bureau (12). The method consists of projecting GDP growth over a given projection period and postulating alternative income distributions at the end of the projection period. The next step consists of projecting agricultural demand by commodity groups as a function of the growth rate of income and the state of income distribution under the various alternatives. Next, agricultural production is independently projected, on a commodity basis, under three technological alternatives: (a) traditional—land expansion with no increase in the use of intermediate or capital inputs; (b) intermediate—land expansion and increased use of intermediate inputs but no further mechanization; and (c)

a number of "users" of sector analysis (i.e., AID, IBRD, OAS, FAO, and representatives of planning commissions of developing countries) prepared short papers outlining what they expected from sector analysis.

modern—land expansion, increased use of intermediate inputs and mechanization). On the basis of the demand and supply projections, a process of reconciliation takes place, and mutually consistent solutions are obtained through a series of iterations. The major feature of this approach is that it permits an evaluation of the effects of alternative technologies on output, employment, and income distribution within a consistent framework. It is true that a number of coefficients and relationships, particularly on the production side, have to be guessed at and that in the process an element of arbitrariness enters the analysis. At the same time, it would appear that this methodology—even though quite rudimentary compared to some of the models reviewed in pages 74–84—can provide important insights about the type of technology which is most in line with the policymaker's preference function. Thus, for example, the results of the Colombian study and of a similar but less ambitious one undertaken on Peru show that the implementation of an agricultural strategy focused on intermediate technology would best fulfill the policymakers' objectives with respect to output, employment and income distribution.⁹

The final partial approach which might be mentioned here would provide a modest bridge between project analysis, on the one hand, and macroeconomic objectives, on the other hand. Clearly a major instrument available to the policymaker in helping him achieve the objectives consists of the allocation of public funds to investment projects and the selection of projects. However, the selection process is typically based on investment criteria, which, by their very use in pre-investment studies, tend to emphasize certain objectives (e.g., output) at the expense of others (e.g., balance-of-payments, employment). It is, therefore, often very difficult to judge whether any given public investment program contributes more or less than another one to the preference function of the government.

A relatively simple methodology was developed to help bridge the gap between macroeconomic objectives and investment criteria, and to relate the project selection process to these objectives (8). The basic feature of this methodology is a function that explicitly incorporates the national economic targets with appropriate weights. Initially, a specific investment criterion is paired with each development objective, be it income-generation, employment creation, or balance-of-payments equilibrium. A ranking function which combines these various objectives is then defined and expressed in ordinal and cardinal terms. This ranking function appears to be a very general and applicable device which can be extended easily to incorporate as many goals as necessary or desired as long as the corresponding investment criteria can be specified and computed.

Although the above approach was only applied to a set of irrigation projects in Peru, it appears to be generally applicable to a wide variety of macroeconomic situations and projects.

The conclusions which emerge from the analysis can be stated briefly. Sector analysis applied to agriculture is still somewhat more of an art than a science. Important methodological contributions are being made by a number of sector

⁹ Furthermore, it is interesting to note that the Peruvian study above revealed that the intermediate strategy would lead to the highest rates of growth of both value added and employment in agriculture as compared to the other strategies. Thus, it would appear that no trade-off between employment and value added—at least within agriculture—need exist in the case of Peru (see 13).

models. However, at this stage, they are, to borrow Professor Hicks's expression, like other metaphysical entities, boats that are loose from their moorings.¹⁰ A concerted effort by technicians and policymakers to continue the dialogue that has been started should lead to more operational relevance, and a better understanding of the problems faced by both groups. It would be surprising if the decade of the 1970s did not go a long way toward bridging the gap between model design and policy requirements.

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¹⁰ I am paraphrasing T. W. Schultz, who used this analogy in a somewhat different sense (see 10, p. 479).